

WHAT IS CLAIMED IS:

1. A control apparatus for an internal combustion engine having a variable valve mechanism capable of changing a valve opening characteristic regarding an open state of an intake valve, and a throttle valve capable of changing a negative pressure in an intake pipe, the control apparatus comprising:
  - 5 a controller capable of controlling the valve opening characteristic and a degree of opening of the throttle valve, the controller being adapted to control an amount of intake air taken into the internal combustion engine through at least one of the control of the valve opening characteristic and the control of the degree of opening of the throttle valve in accordance with an output that is requested of the internal combustion engine,
  - 10 wherein the controller is further adapted to, during a first operation state where the amount of intake air is controlled through the control of the valve opening characteristic control, control the degree of opening of the throttle valve within a range of the degree of opening of the throttle valve that allows maintenance of an atmospheric pressure in the intake pipe under a condition that the valve opening characteristic is in a steady state at least during the first operation state, while maintaining a continuity of the degree of opening of the throttle valve during a period of switch between the first operation state and a second operation state where the
  - 15 amount of intake air is controlled through the control of the degree of opening of the throttle valve only.
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25 2. The control apparatus according to claim 1, wherein the controller is further adapted to maintain the range of degree of opening of the throttle valve that causes presence of the atmospheric pressure in the intake pipe during a transitional period during which the opening valve characteristic is changing.

3. The control apparatus according to claim 1, wherein the variable valve mechanism comprises an electromagnetically-drive valve.

4. A control apparatus for an internal combustion engine having a variable valve mechanism capable of changing a valve opening characteristic regarding an open state of an intake valve, and a throttle valve capable of changing a negative pressure in an intake pipe, the control apparatus comprising:

a controller capable of controlling the valve opening characteristic and a degree of opening of the throttle valve, the controller being adapted to control an amount of intake air taken into the internal combustion engine through at least one of the control of the valve opening characteristic and the control of the degree of opening of the throttle valve in accordance with an output that is requested of the internal combustion engine,

wherein the controller is further adapted to, if a switch between an intake amount control through the control of the degree of opening of the throttle valve and an intake amount control through the control of the valve opening characteristic is requested, cause the requested switch after an output of the internal combustion engine based on a currently performed intake amount control has reached a steady state.

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5. The control apparatus according to claim 4, wherein the requested switch is a switch from the intake amount control through the control of the degree of opening of the throttle valve to the intake amount control through the control of the valve opening characteristic.

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6. The control apparatus according to claim 4, wherein the variable valve mechanism comprises an electromagnetically-drive valve.

7. A control apparatus for an internal combustion engine having a variable valve mechanism capable of changing a valve opening characteristic regarding an open state of an intake valve and an open state of an exhaust valve, the control apparatus comprising:

5           a controller capable of controlling the valve opening characteristic, which is adapted to control an amount of intake air taken into the internal combustion engine through the control of valve opening characteristic in accordance with an output that is requested of the internal combustion engine,

              wherein the controller is further adapted to control the valve opening

10          characteristic so that an opening start timing of the intake valve and a closing timing of the exhaust valve become substantially symmetrical about a timing at which a combustion chamber capacity of the internal combustion engine becomes minimum at least during a predetermined operation state of the internal combustion engine.

15          8. The control apparatus according to claim 7, wherein the variable valve mechanism comprises an electromagnetically-drive valve.

9. The control apparatus according to claim 7, wherein the controller is further adapted to open the intake valve of the internal combustion engine after the exhaust 20 valve has closed if the valve opening characteristic is in a minimum state.

10. The control apparatus according to claim 9, wherein the internal combustion engine has a plurality of cylinders equipped with the variable valve mechanism, and a minimum value of the valve opening characteristic to be controlled 25 by the controller is set within a range that is feasible for all the cylinders.

11. A control method for an internal combustion engine having a variable valve mechanism capable of changing a valve opening characteristic regarding an

open state of an intake valve, and a throttle valve capable of changing a negative pressure in an intake pipe, the control method comprising:

a valve control step of controlling the valve opening characteristic;

a throttle control step of controlling a degree of opening of the throttle valve;

5 and

an intake amount control step of controlling an amount of intake air taken into the internal combustion engine, by using at least one of the valve control step and the throttle control step in accordance with an output that is requested of the internal combustion engine,

10 wherein in the throttle control step, the degree of opening of the throttle valve during a first operation state where the amount of intake air is controlled via the valve control step is controlled within a range of the degree of opening of the throttle valve that allows maintenance of an atmospheric pressure in the intake pipe under a condition that the valve opening characteristic is in a steady state at least during the 15 first operation state, while a continuity of the degree of opening of the throttle valve is maintained during a period of switch between the first operation state and a second operation state where the amount of intake air is controlled by using the throttle control step without using the valve control step.

20 12. A control method for an internal combustion engine having a variable valve mechanism capable of changing a valve opening characteristic regarding an open state of an intake valve, and a throttle valve capable of changing a negative pressure in an intake pipe, the control method comprising:

a valve control step of controlling the valve opening characteristic;

25 a throttle control step of controlling a degree of opening of the throttle valve;

and

an intake amount control step of controlling an amount of intake air taken into the internal combustion engine, by using at least one of the valve control step and the

throttle control step in accordance with an output that is requested of the internal combustion engine,

wherein if a switch between an intake amount control using the throttle control step and an intake amount control using the valve control step is requested, the switch  
5 is performed in the intake amount control step after an output of the internal combustion engine based on a currently performed intake amount control has reached a substantially steady state.

13. A control method for an internal combustion engine having a variable  
10 valve mechanism capable of changing a valve opening characteristic regarding an open state of an intake valve and an open state of an exhaust valve, the control method comprising:

a valve control step of controlling the valve opening characteristic; and  
an intake amount control step of controlling an amount of intake air taken into  
15 the internal combustion engine, by using the valve control step in accordance with an output that is requested of the internal combustion engine,

wherein in the valve control step, the valve opening characteristic is controlled so that an opening start timing of the intake valve and a closing timing of the exhaust valve become substantially symmetrical about a timing at which a combustion chamber capacity of the internal combustion engine becomes minimum at least during  
20 a predetermined operation state.